TWR-77386
ECS SS12944

SPACE SHUTTLE PROGRAM
Space Shuttle Projects Office (MSFC)
NASA Marshall Space Flight Center, Huntsville, Alabama

Reusable Solid Rocket Motor

STS-111 Flight Readiness Review/CoFR

Motor Set RSRM-84

16 May 2002

Presented by Terry Boardman

THIOKOL PROPULSION

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Agenda

Flight Readiness Review/CoFR

1.0 Previous Flight Assessment—STS-110

2.0 Certification Status—**No Constraints**

3.0 Changes Since Previous Flight—**None**

4.0 Configuration Inspection

- 4.1 As-Built Versus As-Designed, Hardware, and Closeout Photo Review Status—**No Issues**
- 4.2 Hardware Changeouts Since ET/SRB Mate Review—**None**

5.0 SMRB Nonconformance—**None**

6.0 Technical Issues/Special Topics

7.0 Readiness Assessment

Backup LCC and Contingency Temperatures for STS-111

Previous Flight Assessment—STS-110

Disassembly Evaluation Summary—Status of Disassembly Activity

KSC Operations		LH RSRM	RH RSRM	Remarks
Initial LH/RH SRB viewing	*	Complete	Complete	
SRB/RSRM walkaround assessment	*	Complete	Complete	
Demate/evaluate aft exit cone (AEC)	*	Complete	Complete	
Remove/evaluate S&A and OPTs	*	Complete	Complete	
Remove/evaluate nozzle	*	Complete	Complete	
Remove/evaluate stiffener rings/stubs		Complete	Complete	
Remove/evaluate igniter	*	Complete	Complete	
Demate/evaluate field joints/evaluate insulation	*	Complete	Complete	
Utah Operations				
Disassemble/evaluate nozzle (joint No. 4 and 5)	*	Complete	Complete	
Disassemble/evaluate nozzle (joint No. 2 and 3)	*	Complete	Complete	
Disassemble/evaluate S&A	*	Complete	Complete	
Washout nozzle phenolics		17 Jul 2002	17 Jul 2002	
Washout nozzle AEC phenolics		17 Jul 2002	17 Jul 2002	
Measure/evaluate aft dome insulation		10 Sep 2002	10 Sep 2002	
Measure/evaluate LH segment and igniter insulation		10 Sep 2002	N/A	

* RSRM Project committed to complete prior to next launch

- **No constraints to STS-111 flight**

Technical Issues/Special Topics

STS-111 Potential Thrust Imbalance (Ref. Waiver RWW0546 and DR 436854-01)

Observation

- STS-111 LH aft segment was not processed from the same propellant evaluation as the other seven segments (original LH aft segment was scrapped due to suspected polymer contamination of inhibitor surfaces)

Concern

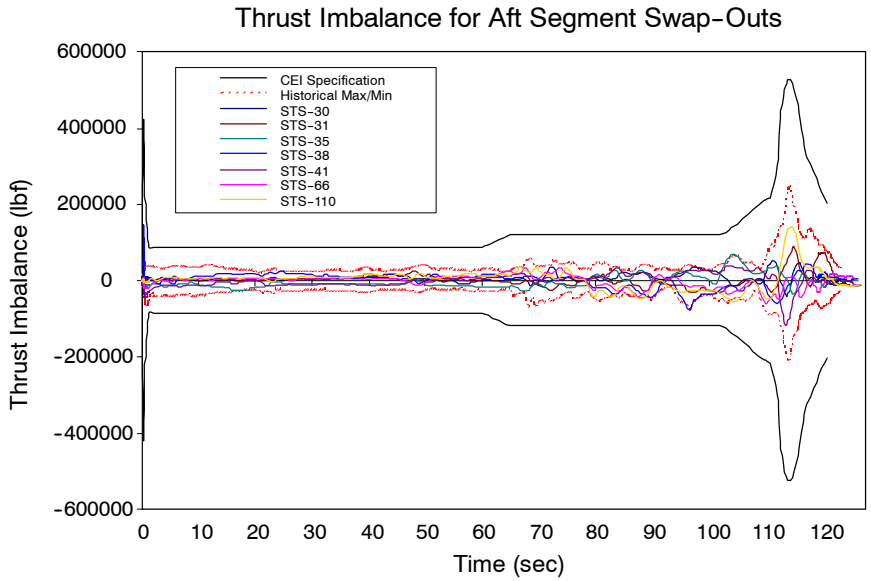
- Potential thrust imbalance exceeding CEI requirements

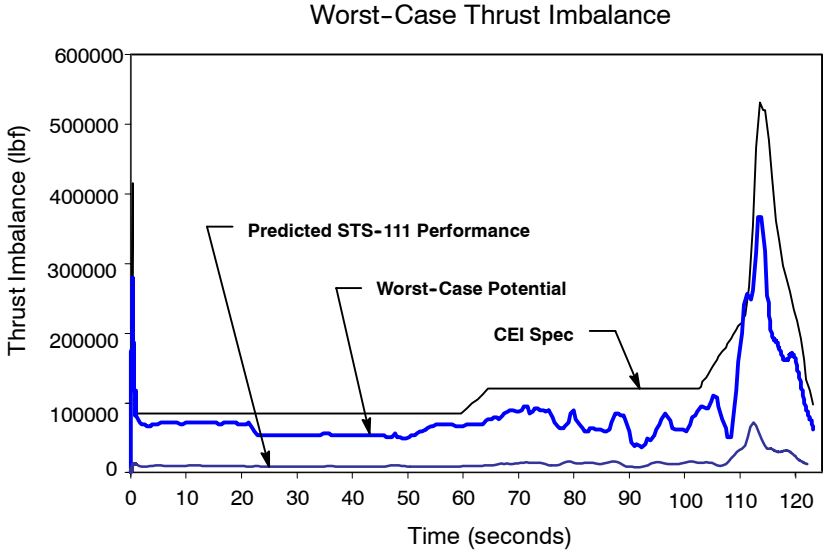
Discussion

- Both LH and RH motors must have nearly the same propellant burn rate characteristics to ensure that the thrust imbalance meets CEI requirements
- All segments in a flight set are cast using the same propellant raw material lots (propellant evaluation) and standardized to achieve the target burn rate by adjusting the iron oxide percentage
- When one segment contains propellent raw materials from a different evaluation, the potential for a thrust imbalance exceeding requirements exists—aft segment replacements have been required seven times in the RSRM program including the previous flight, STS-110
    - All flight sets with replacement segments performed well within CEI requirements
    - STS-111 LH RSRM is predicted to perform within requirements for thrust imbalance

Technical Issues/Special Topics

STS-111 Potential Thrust Imbalance (Cont)





Thrust imbalance = LH RSRM thrust - RH RSRM thrust

Technical Issues/Special Topics

STS-111 Potential Thrust Imbalance (Cont)

Discussion (Cont)

- Worst-case thrust imbalance analyses were conducted by Thiokol and MSFC to assess compliance with requirements
    - Statistical approach used to establish worst-case burn rate differences and trace shape variation between LH and RH motors
    - Worst-case analyses showed that thrust imbalance would exceed CEI specification limits by no more than 23,000 lbf around web time
    - Level III Waiver RWW0546 approved
- Level II Shuttle Controls group evaluated worst-case condition with no impact on vehicle certification
- Level II Waiver (NSTS-07700, Vol X, Book 1, Waiver 689) approved per CR5071765 by PRCB on 8 May 2001

Flight Rationale

- All previous segment changeouts performed nominally
- Flight predictions based on actual burn rates are well within requirements
- No impact to vehicle certification if worst-case thrust imbalance is experienced
- STS-111 is safe to fly

Technical Issues/Special Topics

STS-107 RH Center Field Joint Pin Protrusion

Observation

- During installation of the pin retainer band on the STS-107 RH center field joint the gap between band and outer clevis leg was noted to be more variable than normal (no requirement for gap but typically the gap is constant)
- Pin retainer band was removed—pin protrusion measurements showed 10 pins out of 177 violated the requirement of 0.220-in. maximum—worst case was 0.269 in.
- Pin protrusion did not cause pin retainer band gap irregularities
- Pins are inspected for proper engagement prior to installation of pin retainer band by USA Quality with NASA Quality witness participation—proper pin installation had been recorded for STS-107

Concern

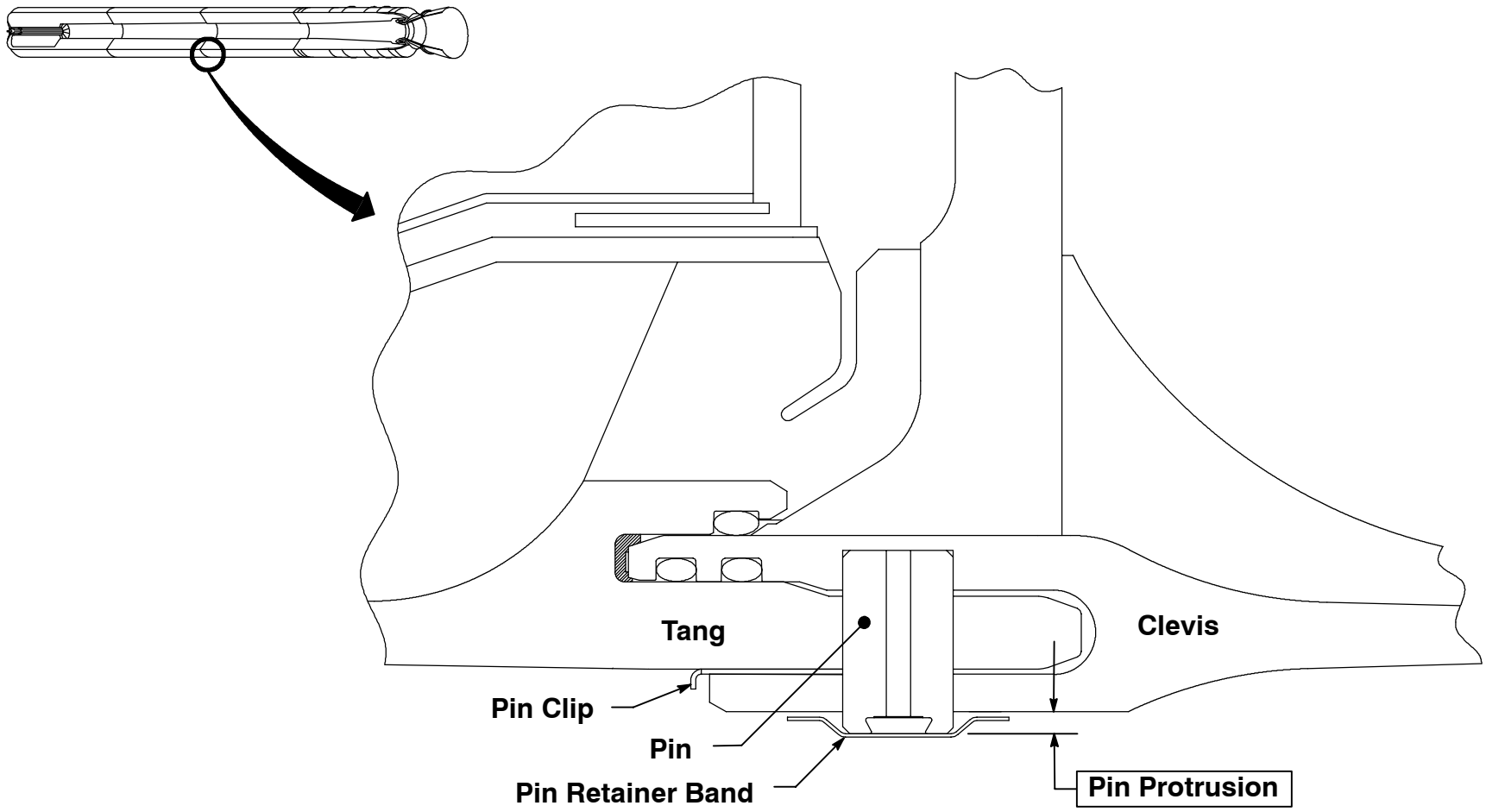
- Potential for improper pin engagement condition on STS-111 and STS-107 impacting the structural and sealing capability of the field joints

Discussion

- Following removal of pin retainer band, discrepant pins were seated to meet 0.220-in. protrusion requirement—one pin remains at 0.224 in.—acceptable condition with positive safety margin

Technical Issues/Special Topics

STS-107 RH Center Field Joint Pin Protrusion (Cont)



Center Field Joint Configuration

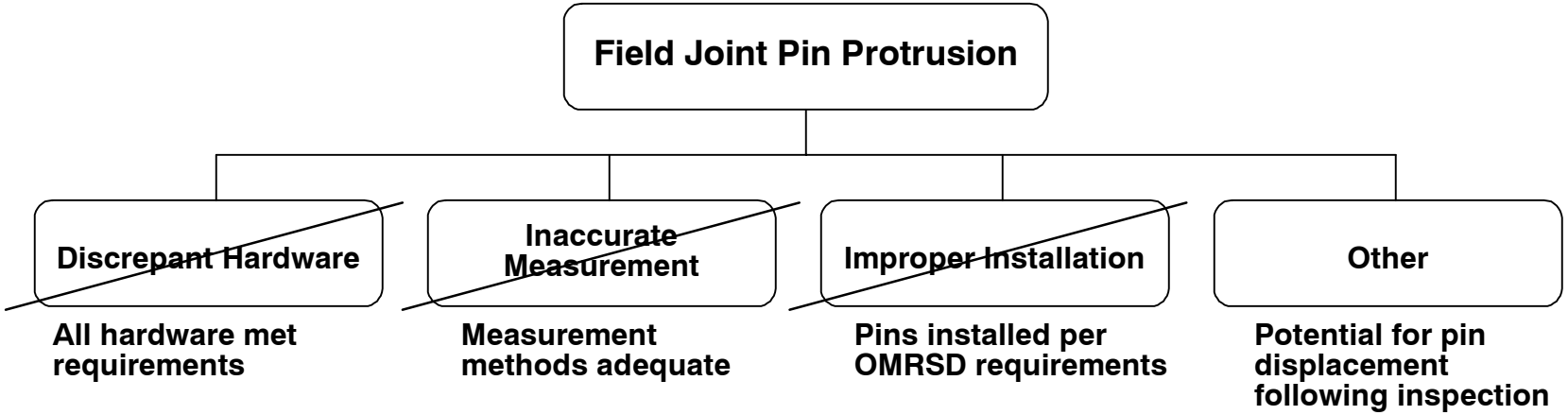
Note: Cork FJPS removed for clarity

Technical Issues/Special Topics

STS-107 RH Center Field Joint Pin Protrusion (Cont)

Discussion (Cont)

- Fault tree approach was employed to ascertain cause of discrepant pin condition:



- Fault tree evaluation indicated most probable cause of discrepant condition was pin displacement following inspection and prior to installation of pin retainer band
- No changes have been made in joint assembly sequence—nothing unusual was noted during assembly of STS-107 center field joint
- Probable that displaced pins have occurred throughout the program

Technical Issues/Special Topics

STS-107 RH Center Field Joint Pin Protrusion (Cont)

Discussion (Cont)

- Analyses were conducted to define pin displacement conditions maintaining a positive structural margin of safety and meeting 2X seal tracking requirements:
  - Analysis using actual material properties shows pin protrusion of 0.262 in. (SF = 1.4/1.1 ultimate/yield) maintains positive MS for pin next to an alignment slot (0.289 in., SF = 1.0)
  - For holes away from alignment slot influence (approximately five holes on each side), protrusion can be 0.284 in. (SF = 1.4/1.1 ultimate/yield) and maintain positive MS (0.321 in., SF = 1.0)
  - With this amount of pin protrusion, there would be no effect on joint gap openings and seals tracking
- Yielding of inner clevis leg blind hole due to excessive pin protrusion would be observed during case refurbishment operations—no such indications noted for current joint configuration (over 72,000 pinholes)

Technical Issues/Special Topics

STS-107 RH Center Field Joint Pin Protrusion (Cont)

Flight Rationale

- No change in joint processing has occurred and no special causes were noted for occurrence of pin protrusion in STS-107 center segment field joint—previous history is applicable to STS-111
- Postflight and refurbishment inspections show no indication of excessive pin protrusion (sufficient to cause yielding of inner clevis leg blind hole) in current joint configuration
- Most probable cause of observed pin displacements on STS-107 were operations conducted following verification of pin seating and prior to installation of pin retainer band—minimal opportunity for significant pin motion
- Joint will function structurally with large pin displacements—most probable condition is small displacement of a few pins
- Suspected condition in STS-111 maintains positive structural margins and 2X seal tracking requirement
- STS-111 and STS-107 are safe to fly

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STS–111 Readiness Assessment

Pending satisfactory completion of normal operations flow (per OMRSD), the RSRM hardware is ready to support flight for mission

STS–111

16 May 2002

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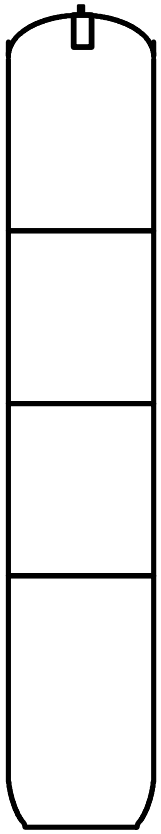
Current Flight Predictions

LCC and Contingency Temperatures for STS-111



Heater Location	LCC	Minimum Allowable Sensor Temperature*	
		LH	RH
Igniter	74°F	72°F	72°F
Forward Field Joint	86°F	66°F	69°F
Center Field Joint	86°F	70°F	70°F
Aft Field Joint	86°F	73°F	72°F
Nozzle-to-Case Joint	75°F	66°F	65°F

*LCC contingency temperature in the event of heater failure
Note: Calculation includes all standard repair conditions